Bokshteyn, S.Z.

Category : USSR/Solid State Physics - Diffusion. Sintering E-6

Abs Jour : Ref Zhur - Fizika, No 3, 1957, No 6689

Author : Mirskiy, L.M., Rakovskiy, V.S., Bokshteyn, S.Z.

Title : Investigation of Diffusion Processes in Sintering, Using Radioactive Isotopes.

Orig Pub : Poroshkovaya metallurgiya, Yaroslavl', 1956, 52-60

Abstract : Preliminary experiments were carried out on producing a procedure for investigating the diffusion during sintering, using radioactive isotopes. The use of the procedure developed made it possible to conclude that the ideas proposed by Ya. I. Frenkel' concerning the "hole" mechanism of diffusion are correct. The coefficients of diffusions have been determined for the alloys W-Ni, TiC-Mo, TiC-W and TiC-Nb. These coefficients make it possible to calculate the activation energy of W, Mo, and Nb and consequently, in final analysis, to determine the strength of the bond in the lattice.

BOKSHTEYN, S. Z.

"Effect of Metal Composition and Structure on Grain Boundary Diffusion," S. Z. Bokshteyn, S. T. Kishkin, and L. M. Moroz, Moscow Aviation Inst, USSR.

Paper submitted for presentation at the International Conference on Radioisotopes in Scientific Research, Paris, 9-20 Sep 1957.

129-2-1/10

AUTHOR: Bokshteyn, S.Z., Dr. of Technical Sciences Prof., Kishkin, S.T., Dr. of Technical Sciences Prof. and Moroz, L.M., Eng.

TITLE: Self-Diffusion of Iron in the Volume of the Grain and Along its Boundaries. (Samodiffuziya zheleza v ob'yeme i po granitsam zerna).

PERIODICAL: Metallovedeniye i obrabotka metallov, 1957, No. 2, pp 2-10 (U.S.S.R.)

ABSTRACT: In a series of papers V.I. Arkharov et alii (14, 15) show, on the basis of metallographic analysis, that there is preferential diffusion of a number of elements along the grain boundaries of iron, nickel and copper. Gruzin, P.L., Kuznetsov, E.V. and Kurdyumov, G.V. (22) studied the diffusion of iron in the alloys iron-nickel and iron-nickel-carbon (25% Ni, 0.69% C) and found that the straight lines expressing the dependence lg D on 1/T show a break at 1000 to 1100°C. The inclination angle at lower temperatures indicates lower values of the activation energy compared with respective high temperature values; this dependence was observed only if the alloy was subjected to martensite transformation prior to diffusion annealing. In fact, the diffusion coefficient at 900°C in this case is three times as large as for specimens which have not been subjected to martensite transformation, i.e. 7.65×10^{-12} and 2.35×10^{-12} cm^2/sec respectively. Apparently, the influence of earlier transformations

APPROVED FOR RELEASE: 06/09/2000 CIA-RDP86-00513R000206110006-5"

TITLE: Self-Diffusion of Iron in the Volume of the Grain and Along its Boundaries. (Samodiffuziya zheleza v ob'yeme i po granitsam zerna).

is nullified only after heating the specimens to 1000 to 1100 C. Earlier investigations by the authors of this paper (21, 23) by means of auto-radiography methods indicates thatthis process is nonuniform in a polycrystalline body and has a pronounced local character. The process of self-diffusion of iron was investigated by means of an auto-radiography method described earlier by the authors of this paper (21,23). 20 x 10 x 10 mm specimens of Armco iron (0.028% C, 0.030% S, 0.017% P, 0.12% Si, 0.22% Mn) were coated with radio-active Fe^{59} in an electrolytic bath of such a composition that the coating can be effected at room temperature, is not liable to oxidation, is stable in operation and does not have to be frequently corrected. During 10 to 15 minutes an 0.2 to 0.5 μ thick radio-active iron layer was deposited with an activity of 4000 to 7000 imp/cm min. For self-diffusion of the iron in the α and the γ states annealing was effected in the temperature range 800 to 1200°C, maintaining the temperature constant within 2°C. At

TITLE: Self-Diffusion of Iron in the Volume of the Grain and Along its Boundaries. (Samodiffuziya zheleza v ob"yeme i po granitsam zerna).

first the qualitative self-diffusion of iron was studied at 800, 1000, 1100 and 1200°C. Fig. 1 shows auto-radiograms of specimens after diffusion annealing at 800,1000 and 1200°C. Fig. 2 shows the measured values of the depth of self-diffusion of iron in the grain for 1000°C. Fib. 3 shows the dependence of the density of blackening on the depth of self-diffusion of iron along the grain boundaries. Fig. 4 shows the temperature dependence of the self-diffusion coefficient of iron inside the grain and along the grain boundaries. Measured values of the influence of the temperature on the coefficient of self-diffusion inside the grain and along the grain boundaries are given in a table on p. 8. As a result of the tests, the character of the process of self-diffusion of iron in the α and the γ states was determined. It is shown that displacement of atoms during self-diffusion of the iron takes place predominantly along the grain boundaries within a wide range of temperatures (800 to 1200°C) and is independent on the type of crystal lattice. For the temperature dependence of the coefficient of self-diffusion of γ iron the relations were determined separately

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TITLE: Self-Diffusion of Iron in the Volume of the Grain and Along its Boundaries. (Samodiffuziya zheleza v ob"yeme i po granitsam zerna).

for the grain boundary and for the grain volume, namely:

$$D_{boundary} = 2.3e^{-30\ 600/RT}$$

$$D_{grain} = 0.16 \times 10^{-6} e^{-64\ 000/RT}$$

Although conserving a high mobility along the crystal boundaries in the case of self-diffusion right up to 1200°C, a decrease is observed in the speed of diffusion with increasing temperatures, namely:

$$D_{boundary}/D_{grain} \text{ (at 1000°C) } 12\ 000$$

$$D_{boundary}/D_{grain} \text{ (at 1200°C) } 2\ 500.$$

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TITLE: Self-Diffusion of Iron in the Volume of the Grain and Along its Boundaries. (Samodiffuziya zheleza v ob"yeme i po granitsam zerna).

The observed differences in the parameters of the self-diffusion of iron inside grains and along the grain boundaries are attributed fundamentally to the features of the structure of the crystal lattice in the boundary zone.

One photo, three graphs, and one table are shown. There are 26 references, of which 12 are Slavic.

ASSOCIATION: ---

PRESENTED BY: ---

SUBMITTED: ---

AVAILABLE: Library of Congress

Card 5/5

Bokshteyn S.Z.

32-12-19/71

AUTHORS: Gudkova, T.I., Gorbatov, V.S., Bokshteyn, S.Z., Zhukhovitskiy, A.A., Kishkin, S.T.

TITLE: A Method of Investigating the Influence Exercised by Tension and Deformation Upon the Self-Diffusion of Iron (Metodika issledovaniya vliyaniya napryazheniya i deformatsii na samodiffuziyu zheleza).

PERIODICAL: Zavodskaya Laboratoriya, 1957, Vol. 23, Nr 12, pp. 1438-1439 (USSR)

ABSTRACT: In an Institute of the AN USSR, which is not mentioned here, a special device was constructed which makes it possible to carry out diffusion red hot heating in the vacuum, in which the diffusion properties of the samples can be investigated by making use of traction at the conditions of elastic and plastic deformation. The apparatus consists of a combination of the test-machine "ВП-8", a steel vacuum camera having a diameter of 200 mm, and containing an electric furnace of 110 mm length and the necessary measuring devices. The flat samples of slightly carboniferous steel (0,1%C; 0,35%Mn; 0,024%P; 0,015%S) were subjected to traction in the machine up to the degree of extension and destruction. Because of the decrease of structural tensions the samples were previously softened in the vacuum at 1000°, after which they were on one side and on a surface of 1 cm² provided with a coating of electrolytic iron which served as diffusion

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A Method of Investigating the Influence Exercised by Tension and Deformation Upon the Self-Diffusion of Iron 32-12-19/71

object. The results obtained are shown together in a table. It was found that the self-diffusion of iron under certain conditions develops mainly according to the structural grain boundaries, and that the circumstances of the application of fraction as well as of the high temperature accelerate the diffusion of iron. The plastic deformation of the sample increases the self-diffusion of iron by nearly the three-fold, which is explained by the atomic motion which sets in. At the same time, however, the activation energy in the corresponding domain of the sample is diminished. Iron with a 0,1%C-content enters into the two-phase state (α - γ) at 750-800°, but because the α-phase remains predominant, it also determines the velocity of the diffusion current. There are 1 table and 9 Slavic references.

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1. Iron-Self diffusion-Determination 2. Instrumentation 3. Iron-Tension 4. Iron-Deformation

BOKSHTEYN, S. Z.

4E2c

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The Effect of Alloying Constituents on Self Diffusion Rate

Dokl.Akad.Nauk 112(4), 1957

M.E. Yanitskaya, A.A. Zhukhovitsky, S.Z. Bokshtein

U.S.S.R.

On the basis of experiments with two systems, self diffusion was studied with the aid of the method of thin layers. The effect of small quantities of alloying constituents on both volume and boundary diffusion is discussed. ~~Bibl. 6.~~

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MT

18(7)

AUTHORS: ~~Bokshteyn, S. Z.,~~ Zhukhovitskiy, A. A., Kishkin, S. T., Mal'tsev, E. R.

SOV/163-58-4-26/47

TITLE: Influence of the Phase Conversion on the Speed of Autodiffusion (Vliyaniye fazovykh prevrashcheniy na skorost' samodiffuzii)

PERIODICAL: Nauchnyye doklady vysshey shkoly. Metallurgiya, 1958, Nr 4, pp 158-161 (USSR)

ABSTRACT: The influence of eutectoid conversion in steel on the speed of autodiffusion in iron is explained. Besides, some experiments were made to measure the effect of polymorphic conversion $\alpha \rightleftarrows \gamma$ on the speed of autodiffusion. The influence of eutectoid conversion (austenite-perlite) in steel U8 (0.78 % C) on the speed of autodiffusion in iron was investigated. For determining the diffusion parameters, the usual variant of the absorption method (Ref 2) was used. The diffusion factor was calculated according to the theory (Ref 3). It is shown that the eutectoid conversion increases considerably the average mobility of the atoms in the lattice. In examining the influence of the polymorphic $\alpha \rightleftarrows \gamma$-conversion on the autodiffusion of iron (0.059 % C), one of the variants

of the absorption method, the so-called "method of the thin layer" (quotation marks in the Russian original) (Ref 2) was used for determining the factors of autodiffusion in iron. The data obtained show that the autodiffusion of iron in cyclic annealing, when the $\alpha \rightleftarrows \gamma$-conversion is imposed on the diffusion process, proceeds at about the same speed as the autodiffusion of α-iron in isothermic annealing at 880°. Thus, the polymorphic conversion does not change the speed of autodiffusion, in contrast to the eutectoid conversion. The formation of the new phase and the corresponding lattice reconstruction may lead to an increase of mobility of the iron atoms on account of a number of causes mentioned here. The polymorphic $\alpha \rightleftarrows \gamma$-conversion has apparently no noticeable influence on the elementary act of autodiffusion of iron. Thus, the two processes may be regarded independent of each other. This result can be explained by supposing that - in the case of substituting a crystalline iron atom packing by another - the atoms do not shift by great distances but only by distances smaller than the interatomic distance. In contrast with the polymorphic conversion, the eutectoid conversion in steel increases the speed of autodiffusion of the iron considerably (by one order of magnitude). There are 1 figure, 2 tables, and 5 references, 4 of which are Soviet.

ASSOCIATION: Moskovskiy institut stali i VIAM (Moscow Steel Institute and VIAM)

SUBMITTED: May 22, 1958

AUTHOR: Bokshteyn, S. Z. SOV/32-24-8-22/4

TITLE: The Use of Radioactive Isotopes in Measuring Local Properties of Alloys (Primeneniye radioaktivnykh izotopov dlya izmereniya lokal'nykh kharakteristik splavov) A Review (Obzor)

PERIODICAL: Zavodskaya Laboratoriya, 1958, Vol. 24, Nr 8, pp. 978-979 (USSR)

ABSTRACT: In this paper a review is given of the various applications of the radiographic method to the study of local properties of alloys. The method itself is first described, and then the application and quality of the photoemulsion are considered. The instructions for using the photoemulsion were worked out by the NIIFI. The autoradiographic methods make it possible to determine variations of concentration in small segments (~10 μ) of alloys, and possess great sensitivity. A number of observations are made on the applicability of the method for local studies. The method has been used to study the distribution of elements in alloys. It has been used to study the process of diffusion in connection with prevailing changes in the structure and properties of alloys. The investigations of S. T. Kishkina and L. M. Motoz were similar to those conducted by the author. The results are given from

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[illegible]OV/[illegible]-[illegible]4-8-[illegible]/43

The Use of Radioactive Isotopes in Measuring Local Properties of Alloys. A Review

Investigations which were made to determine the influence of tiny admixtures of single elements in producing definite, desired properties in alloys. There are [illegible]5 references, [illegible] of which are Soviet.

Card [illegible]/2

BOKSHTEYN

GRUZIN, P. L., FRANTSEVICH, I. N., ZHUKHOVITSKIY, A. A., BORISOV, V. T., and BOKSHTEYN, S. Z.

"Concerning the Diffusion and Electric Transmission of Carbon in Iron and its Alloys"

report presented at the UNESCO Conference on the Utilization of Radioactive Isotopes in Scientific Research, Paris, 9-20 Sept 1957.
Vestnik AN SSSR, 1958, v. 28, No. 1, pp. 71-78. (author Vinogradov, A. P.)

BOKSHTEYN, S.Z.; GUDKOVA, T.I.; ZHUKHOVITSKIY, A.A.; KISHKIN, S.T.

Effect of irreversible structural changes due to plastic deformation on diffusion mobility. Dokl. AN SSSR 121 no.6:1015-1018 A '58.

1. Vsesoyuznyy nauchno-issledovatel'skiy institut aviatsionnykh materialov. Predstavleno akademikom G.V. Kurdyumovym.
(Diffusion) (Deformations (Mechanics))

Bokshteyn, S.Z.

24(6) PHASE I BOOK EXPLOITATION SOV/2385

Akademiya nauk SSSR

Nekotoryye problemy prochnosti tverdogo tela; sbornik statey (Some Problems in the Strength of Solids; Collection of Articles) Moscow, Izd-vo AN SSSR, 1959. 386 p. Errata slip inserted. 2,000 copies printed.

Ed. of Publishing House: V. I. Aver'yanov; Tech. Ed.: R. S. Pevzner; Editorial Board: A.F. Ioffe, Academician; G. V. Kurdyumov, Academician; S. N. Zhurkov, Corresponding Member, USSR Academy of Sciences; B. P. Konstantinov, Corresponding Member, USSR Academy of Sciences; F. F. Vitman, Doctor of Physical and Mathematical Sciences, Professor (Resp. Ed.); L. A. Glikman, Doctor of Technical Sciences, Professor; N. A. Zlatin, Doctor of Physical and Mathematical Sciences; V. A. Stepanov, Doctor of Technical Sciences; Ya.B. Fridman, Doctor of Technical Sciences, Professor; B. S. Ioffe, Candidate of Technical Sciences (Deputy Resp. Ed.).

PURPOSE: This book is intended for construction engineers, technologists, physicists and other persons interested in the strength of materials.

COVERAGE: This collection of articles was compile , by the Otdeleniye fiziko-matematicheskikh nauk AN SSSR (Department of Physical and Mathematical Sciences) and the Fiziko-tekhnicheskiy institut AN SSSR (Institute of Applied Physics, Academy of Sciences, USSR) in commemoration of the 80th birthday of Nikolay Nikolayevich Davidenkov, Member of the Ukranian Academy of Sciences, founder and head of the Otdel prochnosti materialov (Department of the Strength of Materials) at the Institute of Applied Physics, Academy of Sciences, USSR, founder of the Fakul'tet fizicheskogo metallovedeniya (Department of Physical Metallurgy) at the Leningradskiy politekhnicheskiy institut (Leningrad Polytechnic Institute), recipient of the Stalin Prize (1943), the Order of the Red Banner of Labor (1945) and the Order of Lenin (1953). The articles deal with the strength of materials, phenomena of imperfect elasticity, temper brittleness, hydrogen embrittlement, cold brittleness, influence of deformation speed on the mechanical properties of materials, fatigue of metals, and general problems of the strength, plasticity, and mechanical properties of nonmetals. Numerous personalities are mentioned in the introductory profile of Professor Davidenkov. References are given at the end of each article.

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PHASE I BOOK EXPLOITATION SOV/3726

Bokshteyn, Samuil Zeylikovich, Sergey Timofeyevich Kishkin, and Lita Markovna Moroz

Issledovaniye stroyeniya metallov metodom radioaktivnykh izotopov (Study of the Structure of Metals by the Method of Radioactive Isotopes) Moscow, Oborongiz, 1959. 217 p. Errata slip inserted. 3,200 copies printed.

Reviewer: A.A. Zhukhovitskiy, Doctor of Chemistry, Professor; Ed.: A.G. Rakhshtadt, Candidate of Technical Sciences, Docent; Ed. of Publishing House: L.I. Sheynfayn; Tech. Ed.: V.P. Rozhin; Managing Ed.: A.I. Sokolov, Engineer.

PURPOSE: The book is intended for scientific workers and engineers specializing in metallurgy and the physics of metals.

COVERAGE: This book deals with the problem of the nonhomogeneity of metal alloys and the state of the metal at the interfaces, in particular at

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the grain boundaries. The methods and results of investigations of the chemical nonhomogeneity of various alloys and of diffusion along the grain boundaries are presented. The authors devote considerable attention to methods and techniques of using tagged atoms in investigating distribution and diffusion processes. Engineer T.I. Gudkova participated in the experimental investigations of distribution processes of alloy components. The authors thank Professor A.A. Zhukhovitskiy, Doctor of Chemistry, and A.G. Rakhshtadt, Candidate of Technical Sciences. There are 47 references: 35 Soviet, 11 English, and 1 German.

TABLE OF CONTENTS:

BOKSHTEYN, S.Z.

18(7) PHASE I BOOK EXPLOITATION SOV/3355

Akademiya nauk SSSR. Institut metallurgii. Nauchnyy sovet po probleme zharoprochnykh splavov

Issledovaniya po zharoprochnym splavam, t. IV (Studies on Heat-resistant Alloys, vol. 4), Moscow, Izd-vo AN SSSR, 1959. 400 p. Errata slip inserted. 2,200 copies printed.

Ed. of Publishing House: V. A. Klimov; Tech. Ed.: A. P. Guseva; Editorial Board: I. P. Bardin, Academician; G. V. Kurdyumov, Academician; N. V. Ageyev; Corresponding Member, USSR Academy of Sciences; I. A. Oding, I. M. Pavlov, and I. F. Zudin, Candidate of Technical Sciences.

PURPOSE: This book is intended for metallurgists concerned with the structural metallurgy of alloys.

COVERAGE: This is a collection of specialized studies of various problems in the structural metallurgy of heat-resistant alloys. Some are concerned with theoretical principles, some with descriptions of new equipment and methods, others with properties [illegible]. Various phenomena occurring under specified conditions are studied and reported on. For details, see Table of Contents. The articles are accompanied by a number of references, both Soviet and non-Soviet.

Studies (Cont.) SOV/3355

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BOKSHTEYN, S. Z.

PHASE I BOOK EXPLOITATION SOV/3559

Akademiya nauk SSSR. Institut metallurgii. Nauchnyy sovet po probleme zharoprochnykh splavov

Issledovaniya po zharoprochnym splavam, t. 5 (Investigations of Heat-Resistant Alloys, Vol 5) Moscow, Izd-vo AN SSSR, 1959. 423 p. Errata slip inserted. 2,000 copies printed.

Ed. of Publishing House: V.A. Klimov; Tech. Ed.: I.F. Kuz'min; Editorial Board: I.P. Bardin, Academician, G.V. Kurdyumov, Academician, N.V. Ageyev, Corresponding Member, USSR Academy of Sciences (Resp. Ed.), I.A. Oding, I.M. Pavlov, and I.F. Zudin, Candidate of Technical Sciences.

PURPOSE: This book is intended for metallurgical engineers, research workers in metallurgy, and may also be of interest to students of advanced courses in metallurgy.

COVERAGE: This book, consisting of a number of papers, deals with the properties of heat-resisting metals and alloys. Each of the papers is devoted to the study of the factors which affect the properties and behavior of metals. The effects of various elements such as Cr, Mo, and W on the heat-resisting properties of various alloys are studied. Deformability and workability of certain metals as related to the thermal conditions are the object of another study described. The problems of hydrogen embrittlement, diffusion and the deposition of ceramic coatings on metal surfaces by means of electrophoresis are examined. One paper describes the apparatus and methods used for growing monocrystals of metals. Boron-base metals are critically examined and evaluated. Results are given of studies of interatomic bonds and the behavior of atoms in metal. Tests of turbine and compressor blades are described. No personalities are mentioned. References accompany most of the articles.

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The first prize of 10,000 roubles (imeni D. K. Chernov) was awarded to the following team: Professor S. Z. Bokshteyn, Engineer T. I. Gudkova, Doctor of Technical Sciences Professor A. A. Zhukhovitskiy, Doctor of Technical Sciences Professor S. T. Kishkin and Engineer L. M. Moroz for the paper "Investigation of the diffusion and the distribution of components in a real metal by means of radioactive tracers". The work described in this paper represents experimental and theoretical work of fundamental importance on diffusion in alloys as a function of the structure of the metal and the stress field caused by external action. A brief summary is given of this paper and it is stated that it is not only of major theoretical importance but also of practical interest, particularly from the point of view of the problem of high temperature strength.

Results of the 1958 Competition for Obtaining imeni D. K. Chernov and imeni N. A. Minkevich Prizes, Metallovedeniye i termicheskaya obrabotka metallov, 1959, No. 6, pp 62-64

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E073/E535

18.1285

AUTHORS: Bokshteyn, S.Z., Kishkin, S.T., Doctors of Technical Sciences and Osvenskiy, V.B., Engineer

TITLE: Influence of Polymorphous Transformations 18 on Diffusion 18 in Titanium 21

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, 1960, Nr 6, pp 21-26 (USSR)

ABSTRACT: The operating temperature of titanium alloys is usually 450 to 500°C which is not in accordance with the high melting point of the titanium. It can be assumed that the low heat resistance of titanium alloys is due to a certain extent to diffusion processes. According to A. D. McQuillan (Ref 5) the temperature of polymorphous transformation for pure iodide titanium is 882.5°C. At the operating temperatures the α-modification is stable, whilst at the high melting temperature the β-modification is stable. For the purpose of investigating the influence of the allotropic modification of titanium on the diffusion, the authors used iodide titanium of the following composition: 0.015% Mg, 0.01% Si, 0.02% Fe,

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Influence of Polymorphous Transformations on Diffusion in Titanium

$<$ 0.02% Al, $<$0.02% Ni, 0.008% Cr, $<$0.005% Mn, 0.05% C, 0.05% O, 0.025% N. Since it is known that even small quantities of admixtures exert a considerable influence on the temperature of polymorphous transformations and the properties of titanium, the authors also investigated the commercial titanium VT1D of the following composition: 0.3% Fe, 0.15% Si, 0.10% C, 0.05% W, 0.04% N, 0.15% O, 0.015% H. The commercial titanium was produced in a vacuum arc furnace with a consumable electrode with double re-smelting in a step-wise crystallizer. The electrode was made of pressed titanium sponge. The produced ingots were forged into 12 x 12 mm cross-section rods. After descaling these were vacuum annealed at 1300°C for 8.5 hours. The diffusion of lead into the titanium was studied by means of labelled atoms. The diffusion was studied in the temperature range 700 to 1100°C, measuring every 20 hours the integral intensity of the β-radiation. Table 1 gives the obtained coefficients of diffusion of lead into iodide titanium at the

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Influence of Polymorphous Transformations on Diffusion in Titanium

temperatures 700 to 1100°C, whilst Table 2 gives the diffusion coefficients of lead in commercial titanium at the same temperatures. Fig 2 shows the distribution of lead in titanium resulting from diffusion into commercial titanium at 850°C. The authors also investigated the influence of structural transformations during diffusion annealing on the diffusion speed using two batches, one of which was quenched from 1050°C, the other was quenched (after soaking for 100 hours) from 750°C. The respective microstructures are reproduced in Figs 3a and b. The obtained results permit elucidating the apparent contradiction between the high diffusion temperature and low heat resistance of titanium. The low temperature modification of titanium has a high diffusion mobility; the low strength of the interatomic bonds, combined with the high diffusion mobility, leads to a rapid loss of the strength with increasing temperature. However, the high temperature modification of titanium appears to possess a relatively

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Influence of Polymorphous Transformations on Diffusion in Titanium

high strength of the interatomic bonds. The following conclusions are arrived at:

1) The coefficient of diffusion in α-titanium at the transformation temperature is larger by about two orders of magnitude and even more and the activation energy of the process is half that of β-titanium. A qualitatively equal relation is observed in commercially pure titanium but the diffusion mobility in this is considerably lower and the activation energy is higher than in iodide titanium.

2) The difference in the diffusion parameters of α and β-titanium may be due to differing strength of the interatomic bonds or may be associated with structural features of α-titanium.

3) Structural changes in titanium in the process of diffusion annealing lead to an acceleration of the process of diffusion.

There are 3 figures, 2 tables and 17 references, 7 of which are Soviet and 10 English.

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BRONFIN, M.B., BOKSHTEYN, S.Z., ZHUKHOVITSKIY, A.A.

Determination of the diffusion coefficient from the displacement of the activity curve. Zav.lab. 26 no.7: 828-830 '60. (MIRA 13:7)

(Diffusion) (Radioisotopes)

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S/032/60/026/010/007/035
B016/B054

AUTHORS: Bokshteyn, S. Z., Gubareva, M. A., Kishkin, S. T., and Moroz, L. M.

TITLE: Study of the Process of Iron Recrystallization by the Method of Radioactive Isotopes

PERIODICAL: Zavodskaya laboratoriya, 1960, Vol. 26, No. 10, pp. 1111-1114

TEXT: The authors studied the behavior of atoms at the grain boundaries during the recrystallization of iron (content in %: 0.021 C, 0.014 P, 0.011 S, 0.67 Si, 0.07 Al, 0.08 Mn, 0.06 Ni, 0.033 Cu). Samples of this iron were covered with Fe^{59}. In annealing, Fe^{59} spread due to diffusion at the boundaries between the metal grains. This permitted an observation of the local displacement of atoms lying at the boundary during deformation and recrystallization annealing. Iron rods were annealed at 1250°C for 8 h, and then cut into samples (10 × 10 × 20 mm). The riveted layer (70-80μ) was removed by electropolishing in perchloric and glacial acetic acids. An Fe^{59} layer 1.0 μ thick was electrolytically applied to

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Study of the Process of Iron Recrystallization by the Method of Radioactive Isotopes

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the polished surface. Subsequently, the samples were deformed by compression by 10-16% (Fig. 4) and by 45-70% (Fig. 2). Figs. 1-8 show the autoradiogram (a) on the left, and the microstructure (b) on the right on microphotographs. During exposure the samples were protected by a film 1 μ thick (1% of Zapon varnish in the solvent РДВ (RDV)). To produce the autoradiograms, the samples were exposed for several days on photographic plates or films НИКФИ (NIKFI), type МР (MR). The autoradiograms were compared with the microstructure pictures which had been taken by a microscope of the type МИМ-8 (MIM-8). Next, the recrystallization annealing was carried out (Figs. 3, 5-8). A Table on p. 1113 gives the hardness and the methods of treatment for some samples. On the basis of their methods, the authors succeeded in observing the behavior of grain boundaries during plastic deformation and subsequent recrystallization. It was proved that iron recrystallization at relatively low (15%) and high (50-70%) degrees of deformation causes no essential change in the position of atoms laying at the boundary of deformed grains. With a considerable structural change of the metal after a double recrystallization, as well as

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Study of the Process of Iron Recrystallization by the Method of Radioactive Isotopes

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after polymorphous $\alpha \rightarrow \gamma$ transformation, the atoms at the boundaries of the initial bodies are not displaced. In contrast with recrystallization, plastic deformation is accompanied by a considerable displacement of atoms. The results prove that the displacement of grain boundaries during recrystallization and the subsequent growth of grains is connected with a specific mechanism which differs from the ordinary diffusion mechanism. There are 8 figures, 1 table, and 15 references: 4 Soviet, 1 US, 1 Dutch, 1 French, and 4 German.

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BOKSHTEYN, S.Z., doktor tekhn.nauk; GUDKOVA, T.I., kand.tekhn.nauk; ZHUKHOVITSKIY, A.A., doktor khim.nauk, KISHKIN, S.T., doktor tekhn.nauk

Effect of prestressing and of the creep process on diffusion inside and along the grain boundaries. Trudy MAI no.123:35-40 '60. (MIRA 13:8)

(Crystal lattices) (Creep of metals)

S/129/61/000/001/002/013
E111/E135

AUTHORS: Bokshteyn, S.Z., Doctor of Technical Sciences, Professor; Gubareva, M.A., Engineer; Kontorovich, I.Ye., Doctor of Technical Sciences; and Moroz, L.M., Candidate of Technical Sciences

TITLE: Peculiarities of the Diffusion of Carbon in Iron

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, 1961, No. 1, pp. 10-14 (+ 1 plate)

TEXT: Work by two of the authors (Refs 1-4) and by others (e.g. Refs 2, 3) has shown that diffusion is often non-uniform. This effect could be associated with difference in the activation energy of diffusion (Refs 8-10). In this present work the authors studied diffusion of carbon in technical purity iron (0.03% C) and iron alloys with 0.03% C and 0.14, 0.64 or 2.93% Si. Some alloys also contained a third component: 4.56 or 30% Ni, 0.36 or 1.61% Al, 0.88, 3.77 or 14.13% Cr, 0.21 or 3% Mo, 1.19 or 4.97% W, 0.1 or 2.29% Ti. This enabled the influence of carbide-forming and non-forming elements to be compared. Prismatic specimens 20 mm high and with a 10 mm base were used. C^{14} was deposited on the surface

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Peculiarities of the Diffusion of Carbon in Iron

from barium carbonate or from special specimens containing this isotope. The first technique was used for studies in the gamma, the second in the alpha states. Auto-radiographs were obtained on type НИКФИ (NJKFI) plates, contact prints being examined microphotometrically with a type МФ-4 (MF-4) instrument. The diffusion coefficient was calculated by the method of Bokshteyn et al (Ref.11). Microstructural analysis was also carried out. Autoradiographs and microstructures for iron at 950 °C are shown in Fig.1a and b. Autoradiographs at 550 °C for alpha iron (unalloyed and with 0.64% Si, top and bottom, respectively) are shown in Fig.2a and b. Fig.5 shows plots of darkening against depth of diffusion of carbon in the grains (top curve) and along boundaries (bottom curve in each of the two diagrams), for ferrite (550 °C). The influence of concentration of the different alloying elements on depth of diffusion (mm) in iron at 950 °C is shown in Fig.6.

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Peculiarities of the Diffusion of Carbon in Iron

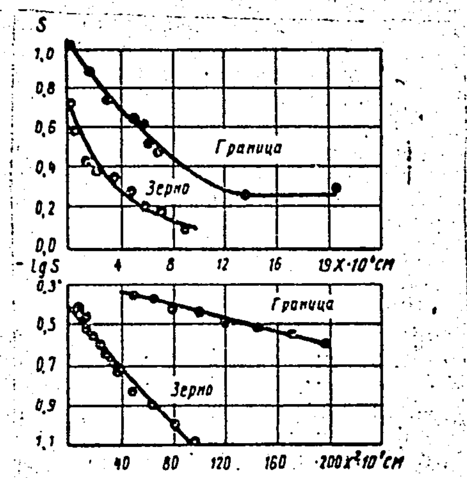

Fig. 5

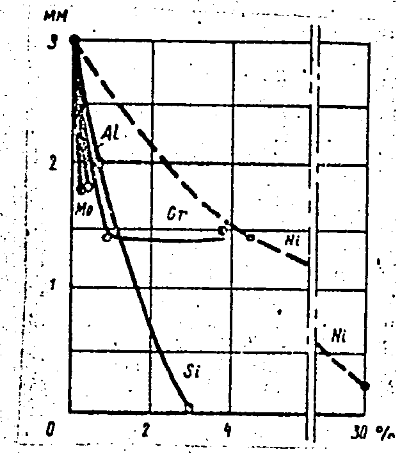

Fig. 6

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Peculiarities of the Diffusion of Carbon in Iron

Fig.7 shows relative darkening with respect to distance into ferrite grain for carbide forming (left-hand graph) and non-forming (right-hand graph) alloying elements. The left and right ends of the plots relate to the grain boundaries; the remaining space, corresponding to 0.30 mm, relates to the body of the grain.

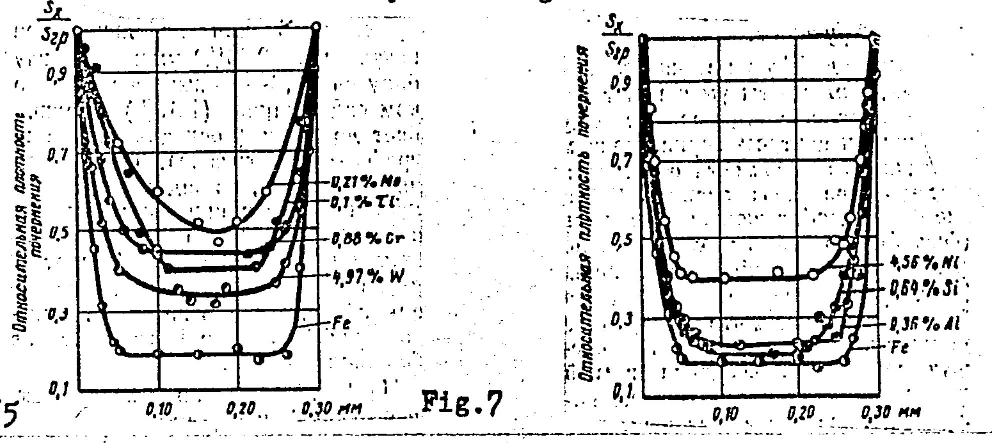

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Fig.7

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Peculiarities of the Diffusion of Carbon in Iron

The work shows that carbon diffusion in both alpha- and gamma-iron occurs unevenly, the grain boundaries and adjacent alpha solid-solution regions becoming enriched with carbon. The diffusion coefficient for grain boundaries is 3-4 orders higher than for inside grains. Alloying modifies both rate of diffusion and distribution of carbon within the grain; depending on the effect of the element on the gamma region. Alloying reduces the carbon-concentration drop between the boundary and the body of the ferrite grain.
There are 7 figures and 11 references: 7 Soviet and 4 non-Soviet.

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E111/E135

AUTHOR: Bokshteyn, S.Z., Doctor of Technical Sciences, Professor

TITLE: Diffusion and structure of metals

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, no.11, 1961, 2-11

TEXT: Diffusion governs many structural changes in metals and can be greatly affected by small changes in the structure. The theory of the process and much of the data have been obtained for idealized conditions, without taking into account real conditions as determined by: 1) internal structural factors (e.g. the existence of boundary surfaces), high-temperature structural and phase changes; 2) external forces acting on the metal (e.g. an electrical field). The author, who has made many contributions to the subject, surveys the field, but does not consider the influence of macroscopic structural defects, pores and cracks on diffusion. He deals first with the role of structure in diffusion. I.C. Fisher (Ref.1: Journal Appl. Phys., no.1, v.22, 1951) made a theoretical analysis of the role of grain boundaries, treating them (in a real crystal) as a slit perpendicular to the specimen surface

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and dividing two semi-infinite volumes corresponding to the grains. A more complicated and rigid treatment followed and extended to include the equilibrium distribution of components between the surface and body (Ref.4: S.Z. Bokshteyn, S.T. Kishkin, L.M. Moroz, Study on the structure of metals by the method of radioisotopes, Metallurgizdat, 1959). A real crystal has also been treated (Ref.5: B.S. Bokshteyn, I.A. Magidson, I.L. Svetlov, Fizika metallov i metallovedeniye, v.6, no.6, 1958) as an array of spherical grains, taking the boundary width as 5×10^{-6} cm, the value in the original treatment (Ref.1) being 5×10^{-8} cm. The effect of sub-structure on diffusional mobility has been examined (Ref.7: B.S. Bokshteyn, T.I. Gudkova, Izv. vysshikh uchebnykh zavedeniy, Chernaya metallurgiya, no.5, 1960), it being found that the diffusion coefficient could be several orders greater along block boundaries than inside grains; the thickness of the boundary-adjacent layer for self-diffusion of iron was found to be about 10^{-6} cm, the activation energy being about 30 000 cal/g.atom. The activation energy for self-diffusion in pure metals is well represented by the empirical relation of

V.Z. Bugakov (Ref.9: Diffusion in metals and alloys, Gostekhizdat, 1949) that it is 40 times the fusion temperature, and it has been concluded (Ref.10: M.Ye. Yanitskaya, A.A. Zhukhovitskiy, S.Z. Bokshteyn, DAN SSSR, v.112, no.4, 1957) that the diffusion activation energy, in contrast to purely thermodynamic properties, greatly affects metal structure. Any crustal-structure disturbance facilitates diffusion. In the next section the author considers the grain boundary, substructure and diffusion. At grain boundaries, whose structure always differs from that of the grain (Ref.11: Metal Interfaces, Cleveland A.S.M., 1952) there is an extra 2000-5000 cal. of energy per mol, the activation energy for self-diffusion being about halved. The high mobility along grain boundaries has been clearly demonstrated for self-diffusion (e.g. Ref.14: S.Z. Bokshteyn, S.T. Kishkin, L.M. Moroz, Zavodskaya laboratoriya, no.3, 1957), autoradiographically; this is the only method by which the persistance of the predominance of self-diffusion along grain boundaries to high temperatures can be demonstrated. An exception to the general rule is titanium, in which diffusion of, for instance, iron is quicker through the grain than along the grain boundary. Contrary to some views

(Ref.16: Ya.S. Umanskiy et al., Physics of Metals, Metallurgizdat, 1955) preferential diffusion along boundaries occurs in interstitial solid solutions, e.g. diffusion of carbon in alpha- and gamma-iron. The enormous effect of grain boundaries on diffusion is associated with their structural peculiarities, as confirmed by the influence of the degree of disorientation of adjacent grains (e.g. Ref.18: R. Franger, Smoluchowski, R., Journal Appl. Phys. no.7, v.22; M. Achter, R. Smoluchowski, Phys. Rev., v.76, 1949). The influx of atoms to the boundary is not balanced by their eflux, and this can lead to a local excess of vacancies. Block boundaries also play a part (e.g. Ref.32: S.Z. Bokshteyn, S.T. Kishkin, V.Ye. Osvenskiy, Metallovedeniye i termicheskaya obrabotka metallov, no.6, 1960) as can retained internal separation surfaces (Ref.23: P.L. Gruzin, Ye.V. Kuznetsov, G.V. Kurdyumov, Symposium 'Problems of Science of Metals and Physics of Metals', no.4, 1954). Dealing with diffusion along external metal surfaces and surface layers, the author states that this has been studied least, although some work has been done (e.g. Ref.26: R. Nickerson, E. Parker, TASM, 42, 1950). With a compacted powder such diffusion can be studied conveniently. For example (Ref.30: B.S. Bokshteyn, D.K. Belashchenko, A.A. Zhukhovitskiy, Izv. AN SSSR, OTN, Metallurgiya i toplivo, no.6, 1960) surface-diffusion coefficients and activation energy (approximately 11000-12000 cal/g. atom) for tin in nickel have been determined. The effect of phase boundaries on diffusion rate has not been confirmed experimentally. In the next section the author deals with phase transformations, crystal structure and diffusion in metals. He and others (Ref.31: S.Z. Bokshteyn, A.A. Zhukhovitskiy, S.T. Kishkin, E.R. Mal'tsev, Nauchnyye doklady vysshey shkoly, no.4, 1958) have shown that the polymorphous $\alpha \rightleftarrows \gamma$ transformation does not increase the self-diffusion of iron whereas the complex eutectoid transformation does. They have also shown (Ref.32: S.Z. Bokshteyn, S.T. Kishkin, V.E. Osvenskiy, Metallovedeniye i termicheskaya obrabotka metallov, no.6, 1960) that in titanium alloys recrystallization can increase mobility of tin. This is to be attributed to differences in the internal boundaries rather than differences in packing density. After ageing a nickel alloy the grain-boundary diffusion rate of tin is reduced to 1/5 that in the hardened alloy. The author attributes observed wire movements to thermodynamic factors rather

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author draws attention to the 10^{13}-fold difference between the experimentally determined value of the pre-exponential factor and that calculated, assuming a simple diffusion mechanism. Although a new structure is formed (Ref.44: S.Z. Bokshteyn, M.A. Gubareva, S.T. Kishkin, L.M. Moroz, Zavodskaya laboratoriya, no.10, 1960) the location of atoms of the iron and nickel at the initial boundaries of the deformed metal is not affected by recrystallization. This holds also for atoms of impurities forming substitutional solid solution with iron but not if the solid solution is interstitial (carbon in iron), when a specific mechanism different from ordinary diffusion comes into play.
There are 6 figures, 2 tables and 46 references: 23 Soviet-bloc, 2 Russian translations from non-Soviet-bloc authors and 21 non-Soviet-bloc. The four most recent English language references read:
Ref.2: R.T. Wipple, Phil. Mag., v.45, no.371, 1954.
Ref.8: A.A. Heudrickson, E.S. Machlin, Journal of Metals, no.9, v.6, 1954.
Ref.19: Jukawa, M. Sinnot, Journal of Metals, no.9, v.7, 1955.
Ref.45: R. Balluffi, Z. Seigle, Journal Appl. Phys., v.25, 1954.

than differences in mobility of the components. The effect of stress and deformation on diffusion is next considered. The author and others have shown (Ref.34: S.Z. Bokshteyn, T.I. Gudkova, A.A. Zhukhovitskiy, S.T. Kishkin, DAN SSSR, v.121, no.6, 1958, and Ref.35: S.Z. Bokshteyn, T.I. Gudkova, A.A. Zhukhovitskiy, S.T. Kishkin, Some Problems of Strength of Solids, AN SSSR, 1959) that tensile stresses increase both self- and hetero-diffusion, the rise in the low elastic-plastic region being 2-3 fold, and considerably more in the plastic region (Ref.34). The relative change decreases with increasing temperature. Irreversible structural changes produced by plastic deformation have an important effect (Ref.34). The initial deformation of tin in nickel is only restored after annealing at 1200 °C (Ref.35). Deformation leads to a high surface diffusional mobility; this effect decreases rapidly with increasing depth, disappearing within a few microns. The author points out that diffusion influences the high-temperature fractures of metal, through vacancy distribution and pore formation and development (e.g. Ref.40: Ya.Ye. Geguzin, Fizika metallov i metallovedeniye, no.5, vol.1, 1957). Discussing recrystallization and diffusion the

BLANTER, Mikhail Yevseyevich; BOKSHTEYN, S.Z., red.; BERLIN, Ye.N., red. izd-va; VAYNSHTEYN, Ye.B., tekhn. red.

[Phase transformations during the heat treatment of steel] Fazovye prevrashcheniia pri termicheskoi obrabotke stali. Moskva, Gos. nauchno-tekhn.izd-vo lit-ry po chernoi i tsvetnoi metallurgii, 1962. 268 p. (MIRA 15:2)
(Steel—Heat treatment)
(Phase rule and equilibrium)

ALFEROVA, N.S., doktor tekhn. nauk; BERNSHTEYN, M.L., kand. tekhn. nauk; BLANTER, M.Ye., doktor tekhn. nauk; BOKSHTEYN, S.Z., doktor tekhn.nauk; VINOGRAD, M.I., kand. tekhn.nauk; GAMOV, M.I., inzh.; GELLER, Yu.A., doktor tekhn. nauk; GOTLIB, L.I., kand. tekhn. nauk; GRDINA, Yu.V., doktor tekhn.nauk; GRIGOROVICH, V.K., kand. tekhn. nauk; GULYAYEV, B.B., doktor tekhn. nauk; DOVGALEVSKIY, Ya.M., kand. tekhn. nauk; DUDOVTSEV, P.A., kand. tekhn. nauk [deceased]; KIDIN, I.N., doktor tekhn. nauk; LEYKIN, I.M., kand. tekhn. nauk; LIVSHITS, B.G., doktor tekhn. nauk; LIVSHITS, L.S., kand.tekhn. nauk; L'VOV, M.A., kand. tekhn. nauk; MEYERSON, G.A., doktor tekhn. nauk; MINKEVICH, A.N., kand. tekhn. nauk; NATANSON, A.K., kand. tekhn. nauk; NAKHIMOV, A.M., inzh.; NAKHIMOV, D.M., kand. tekhn. nauk; OSTRIN, G.Ya., inzh.; PANASENKO, F.L., inzh.; SOLODIKHIN, A.G., kand. tekhn.nauk; KHIMUSHIN, F.F., kand. tekhn. nauk; CHERNASHKIN, V.G., kand. tekhn. nauk; YUDIN, A.A., kand. fiz.-mat. nauk; YANKOVSKIY, V.M., kand. tekhn. nauk; RAKHSHTADT, A.G., red.; GORDON, L.M., red. izd-va; VAYNSHTEYN, Ye.B., tekhn. red.

(Continued on next card)

ALFEROVA, N.S.---- (continued) Card 2.

[Metallography and the heat treatment of steel]Metallovedenie i termicheskaia obrabotka stali; spravochnik. Izd.2., perer. i dop. Pod red. M.L.Bernshteina i A.G. Rakhshtadta. Moskva, Metallurgizdat. Vol.2. 1962. 1656 p. (MIRA 15:10)

(Steel--Metallography)
(Steel--Heat treatment)

33464

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E073/E335

AUTHORS: Kishkin, S.T., Corresponding Member of the AS USSR,
Lozinskiy, M.G., Doctor of Technical Sciences,
Bokshteyn, S.Z., Doctor of Technical Sciences, Professor,
Sokolkov, Ye.N., Candidate of Technical Sciences

TITLE: Influence of high-temperature plastic deformation on the mechanical properties of heat-resistant nickel-base alloys

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, no.1, 1962, 38-40 + 1 plate

TEXT: Two Ni-Cr-base alloys were investigated: the low-carbon ЭИ437Б (EI437B) alloy of the standard composition and the ЭИ617 (EI617) alloy, containing 0.12% C and additions of W and Mo. The alloy EI437B was subjected to the following thermo-mechanical treatment: blanks of 16 mm diameter were first soaked for 8 hours at 1080°C and rolled at this temperature at a rolling speed of 4.5 m/min to 30% reduction. 0.2 to 0.3 sec after deformation, the blanks were quenched to supercool the austenite

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Influence of ...

and to retain the structure, produced as a result of high-temperature plastic deformation. The blanks were then aged at 700°C for 16 hours. Blanks of the alloy EI617 were heated to 1200°C and stamped in a press, so that an average reduction of 30% was achieved; this was followed by quenching in water. The blanks were then aged at 800°C for 16 hours. The results of static tensile and impact tests at room temperature are given in Table 1. Studies of the influence of thermomechanical treatment on the creep strength of austenitic steels revealed that recrystallization should be prevented during high-temperature plastic deformation since it would cancel out the beneficial effects of the thermomechanical treatment. Microstructural investigations correlated with the results of mechanical tests indicate that the increase in strength and ductility occurs even if recrystallization has not been fully suppressed. The increase in strength is attributed to an increase in the quantity of the carbide phase, to changes in the finely crystalline

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Influence of ....

structure of the material and to texturing. The large increase in the ductility of the investigated alloys is obviously due to the absence of intercrystalline fracture. The following participated in the experiments: N.I. Korneyev; T.A. Gordeyeva, Ye.I. Razuvayev, O.N. Podvoyskaya, M.N. Kozlova, L.M. Strizhevskaya, T.A. Volodina, N.F. Lashko, E.V. Polyak, G.N. Korableva, A.V. Bulanov, M.I. Spektor and I.G. Skugarev. There are 2 tables and 7 references: 4 Soviet-bloc references and 3 non-Soviet-bloc. The three English-language references mentioned are: Ref. 4: E.B. Kula, J.M. Ohosi - "TASM", v.52, 1960; Ref. 5: D.J. Schmatz, J.C. Shyne, V.F. Zackay - Metal Progress, v.76, no. 3, 1959; Ref. 7: E.B. Kula, S.L. Lopata - Trans. AIME, v.215, 1959.

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Table 1:

Alloy	Treatment	Mechanical Properties					
		$\sigma_{0.2}$, kg/mm^2	σ_b, kg/mm^2	δ, %	ψ, %	a_k, kgm/cm^2	HB (d_{omn}, mm)
EI437B	Standard (reference specimens)	-	97.0	25.0	20.9	-	-
	TMO *	-	119	32.0	30.7	-	-
EI617	Standard (reference specimens)	71.7	103.7	14.6	10.1	1.8	3.6
	TMO*	93.8	129.6	31.2	25.9	7.8	3.35

* Plastic deformation of supercooled austenite followed by conventional hardening and tempering treatment.

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37728

S/180/62/000/002/001/018
E193/E383

1.1700

AUTHORS: ~~Bokshteyn, S.Z.~~, Kishkin, S.T., Lozinskiy, M.G. and Sokolkov, Ye.N. (Moscow)

TITLE: Thermomechanical treatment of a chromium-nickel-manganese austenitic steel

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Otdeleniye tekhnicheskikh nauk. Metallurgiya i toplivo, no. 2, 1962, 15 - 21

TEXT: The, so-called, "thermomechanical treatment" (TMO) consists essentially of combining plastic deformation at temperatures above the recrystallization temperature with quenching under conditions precluding recrystallization of the plastically deformed material. The effect of this treatment on the structure and properties of various materials has already been studied by other workers. Some additional data on TMO of austenitic steels are presented in the present paper, with particular reference to the properties of these steels after TMO to the ageing treatment and to some characteristics of the diffusion processes. The experiments were conducted on chromium-

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nickel-manganese austenitic steel ЭИ 481 (EI481) specimens, 13 and 60 mm in diameter, the former 150 and the latter 250 mm long. The plastic-deformation part of TMO was effected by rolling at 2.4 m/min in the case of specimens 60 mm in diameter and at 4.5, 7.5 and 13.5 m/min in the case of 13 mm diameter specimens. 25 and 30% reduction was given in each case. Recrystallization of the 13 mm diameter specimens was suppressed by immediate quenching in a water tank mounted on the rolls housing, the time interval between completion of the rolling operation and quenching amounting to 0.2 to 0.3 sec. Rapid cooling of the 60 mm diameter specimens was attained with the aid of a specially designed spraying device. Preheating of the test pieces for rolling was done in air in an electric furnace, the preheating temperature and time being 1 180 °C and 2 hours, respectively. TMO of small (13 mm diameter) test pieces was carried out after cooling them from 1 180 to 1 100 °C. In the case of large (60 mm diameter) test pieces TMO was applied at the preheating temperature and after cooling

to 1 150, 1 100, 1 050 and 1 000 °C. A number of test pieces were given conventional treatment (water-quenching) to obtain control specimens for comparison. All the test pieces (whether quench-hardened or subjected to TMO) were aged at 680 °C for 10 hours, after which they were given an additional treatment of 10 hours at 790 °C, followed by air-cooling so as to attain hardness corresponding to the indentation diameter $d_{отп}$ = 3.5 - 3.7 mm. In addition to standard tensile tests at room temperature, tests at 650 °C were carried out under conditions of short and prolonged loading, the latter (i.e. creep) tests being conducted under an applied stress of 39 or 43 kg/mm². To study and compare the progress of diffusion processes in material subjected to TMO or given the conventional treatment, the rate of diffusion was measured by a radioactive-tracer technique, entailing cutting a taper section across the diffusion region.
A thin film of Fe^{59} was electrodeposited on the specimens studied, which were then given a 150-hours diffusion-annealing treatment at 800 °C in vacuum, after which both volume and grain-boundary

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Thermomechanical treatment ....

diffusion coefficients were determined. Overall diffusion coefficients were also calculated with the aid of the absorption method. Phase-analysis was used to study the effect of hot plastic deformation on the process of carbide-formation during ageing. Electrolytic extraction of the carbide phase from various test pieces was carried out in a 5% solution of hydrochloric acid in methanol. The anode residues were also examined by X-ray diffraction measurements. Preliminary examination of the microstructure revealed that, irrespective of the rolling speed employed during TMO, full suppression of recrystallization had been achieved in small (13 mm diameter) test pieces only. None of the TMO procedures used on large (60 mm diameter) test pieces had ensured suppression of the recrystallization process. The results of standard tensile tests at 20 and 650 °C, carried out on small specimens, showed that TMO brought about a slight increase in UTS at 20 °C (from 108 - 114 kg/mm^2) but had no effect on the strength of steel at 650 °C. The variation in plasticity was somewhat different.

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Thus, as the rolling speed during TMO increased, the elongation of steel at room temperature decreased below that of specimens heat-treated in the conventional manner and then increased to exceed this value. The same applied to reduction in area which, after TMO entailing deformation by rolling at 13.5 m/min, attained a value of 33.2%, i.e. 25% higher than the value attained after conventional treatment. The results of tensile tests at 650 °C also showed a slight increase in elongation of specimens subjected to TMO, although reduction in area of specimens rolled at 13.5 m/min was somewhat lower than that of the control test pieces. The results of accelerated creep tests conducted on small test pieces under a stress of 43 kg/mm^2 showed that irrespective of the conditions during TMO, the time-to-rupture of the steels studied increased after this treatment by 20-25%. The corresponding increase for specimens tested under a stress of 39 kg/mm^2 amounted to 600%. Metallographic examination of small specimens showed that recrystallization during TMO had been completely suppressed in each of the specimens examined. This was indicated by the absence of new small crystals which
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were usually formed in recrystallized material along the boundaries of the original grains. A common specific structural feature of all specimens subjected to TMO was distortion of grain boundaries which had assumed a characteristic serrated contour. A distinguishing feature of specimens rolled during TMO at a speed of 4.5 m/min was well-developed sub-structure. The formation of sub-structure was associated with the formation of blocks (several tens of microns in size) in the interior of the grains. The relatively large angular misalignment of these blocks was indicated by the ease with which the block boundaries could be revealed by etching. No such clearly defined sub-structure was observed in specimens rolled during TMO at higher speeds, although in a few isolated instances there was some evidence of block formation. The formation of the fine structure could be attributed to polygonization processes and subsequent decoration of the low-angle boundaries by the solute atoms and second-phase particles. Another specific feature of the structure produced by TMO is the fragmentation of grains, i.e. sub-division of grains into parts whose dimension are commeasurable with the size of the grains themselves. It would appear that fragmentation is mainly a result of intensive twinning taking place during hot plastic deformation. As stated already, none of the TMO procedures applied to large (60 mm diameter) test pieces ensured complete suppression of recrystallization, the extent of which increased with depth so that an unrecrystallized structure was observed only in the very surface layers of the material. In this case TMO had practically no effect on the resistance-to-creep of the steels studied. The results of phase analysis showed that although the chromium-carbide content of specimens subjected to TMO had increased considerably, it was independent of the rolling speed employed in the course of this treatment. The vanadium-carbide content of the material was practically unaffected by TMO. Finally, the results of diffusion studies indicated that after TMO the coefficient of volume diffusion of iron in steel at 800 °C increased fourfold. Since, owing to a general increase in the diffusion mobility, difficulties were encountered in determining the grain-boundary diffusion coefficient, the overall diffusion coefficients were measured by the absorption method. Comparison of the results obtained for test pieces with different structures showed that the overall diffusion coefficient for materials which had undergone TMO was more than twice as high as that for specimens given the conventional treatment. The general conclusion reached was that in addition to the previously established strengthening effect of grain-boundary distortion caused by TMO, the beneficial effect of this treatment on the high-temperature properties of steel was associated with an increase in the quantity of the strengthening phase and, possibly, with refinement of the mosaic structure and formation of slight texture. There are 4 figures and 2 tables.

SUBMITTED: October 11, 1961

34841
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E111/E335

18.7500

AUTHORS: Bokshteyn, S.Z., Doctor of Technical Sciences, Professor, Kishkin, S.T., Corresponding Member of the Academy of Sciences and Moroz, L.M., Candidate of Technical Sciences

TITLE: Influence of carbon on the movement of grain boundaries in the recrystallization of iron

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, no. 3, 1962, 8 - 13

TEXT: Lücke and Detert (Ref. 1 - Acta Metallurg, v.5, no. 11, 1957) and Beck (Ref. 2 - Metal Interfaces, Cleveland ASM, 1952) consider that there is a sharp drop in the speed of recrystallization when the concentration of an impurity reaches some critical value (about 0.01%) below the solubility. Impurities forming a second phase also retard the growth of recrystallization centres. Using their radioactive-isotopes technique (Ref. 6 - "Zavodskaya laboratoriya, no. 10, 1960) the present authors and M.A. Gubareva have studied the influence of carbon on the behaviour of grain boundaries in the recrystallization of

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technical-grade iron. Carbon was chosen as an element practically insoluble in alpha-iron; it is known to lead to an increase in the activation energy of recrystallization of iron and, if present in quantities even slighly in excess of its solubility, to prevent collective recrystallization, particularly at 620 - 700 °C. Specimens were saturated with carbon from donors at 700 °C for 2 hours. The behaviour of carbon atoms at iron-grain boundaries was followed directly during deformation and subsequent recrystallizing annealing. Recrystallization was studied on specimens 10 - 15 and 50 - 70% deformed, the first being in fact close to the critical value. Autoradiograms obtained before and after deformation were compared. From this and the microstructure the behaviour of the carbon was evaluated. The sizes of all grains increased after deformation; heating to 550 °C failed to produce recrystallization but growth of alpha-phase grains occurred. Carbon tended to move towards grain boundaries even when this meant going into a region of higher carbon concentration. At 650 °C recrystallization was almost complete, the carbon remaining at

APPROVED FOR RELEASE: 06/09/2000 CIA-RDP86-00513R000206110006-5"

the grain boundaries produced after heating at 550 °C. Although recrystallization was practically instantaneous, a completely new fine-grained structure was produced. Heating to 750 °C produced growth of recrystallized grains and movement, not always complete, of carbon to the new grain boundaries. Recrystallization annealing at 700 °C for 45 min of specimens after 13% deformation gave little change in microstructure; carbon moved from the boundaries of deformed grains to those of the new recrystallized grains. The influence of the alpha-gamma transformation on the behaviour of carbon atoms located at boundaries was studied in another series of experiments. For this purpose specimens were heated at 950 °C for 1 hour. Completely new grains were produced, the carbon both migrating to them and forming large accumulations of carbides. It is evident that the behaviour of impurity atoms located at boundaries and forming interstitial solutions is very different from that of boundary atoms of the base element; as shown previously (Ref. 6), boundary atoms in iron recrystallization (or polymorphic transformation) remain in practically the same position; carbon atoms follow newly-formed grain boundaries.

There are 8 figures and 1 table.

X

S/806/62/000/003/002/018

AUTHORS: Bronfin, M. B., ~~Bokshteyn, S. Z.~~, Kishkin, S. T.

TITLE: The self-diffusion of molybdenum in molybdenum-zirconium alloys.

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Issledovaniye splavov tsvetnykh metallov. no. 3. 1962, 12-18.

TEXT: The paper describes experimental work done to clarify the dependence of the volumetric self-diffusion (SD) parameters of Mo on two factors: (1) the amount of alloying Zr present; (2) the antecedent cold-working of Mo alloys. The work is intended as a contribution to correlations between the rate of self-diffusion and creep, such as those which O. D. Sherby, R. L. Orr, et al. have tried to establish causally (J. of Metals, v. 6, no. 1, Sect. I, 1954, 71-79; Trans. ASM, v. 46, 1954, 113-128). Test material and methodology: Large-grain specimens were used to reduce the share of boundary diffusion in the total diffusional flux. The Mo and its Zr alloys were vacuum arc-smelted, rolled into an 18-mm diam rod, and high-T annealed at above 1700°C; the alloys ranged from 0.005% Zr to 0.54% Zr. Right-cylindrical plane-parallel specimens 14-mm diam, 4-mm high, were cut out of the rods and were subjected to a 10-15-hr stabilizing anneal at 1,950-2,000°C in a 10^{-3}-10^{-4} torr vacuum, whereupon the grain size in all specimens attained 1-2 mm.

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Part of the specimens were upset on a press at 20° (height reduction 25%) to investigate the effect of cold working on the SD of the Mo. The specimens were electrically polished, whereupon one of their faces was activated with radioactive Mo^{99} in a galvanic bath. Diffusion anneal was then performed in a special vacuum furnace (exploded view shown) at 10^{-3}-10^{-4} torr and 1,720-2,000°C. The SD coefficient was measured by the two senior authors' method (Zavodskaya laboratoriya, no.7, 1960, 828-830) based on the shift in the activity curve (summarized). Test results: The self-diffusion parameters measured (and tabulated) indicate an appreciable augmentation effect of even small additions of Zr on both the self-diffusion activation energy of the Mo and the factor before the exponential term. Thus, at T above 2,000°C the SD coefficient of Mo does not depend on the alloying, but at T below 1,700°, in which the value of the activation energy is decisive, the SD rate decreases with increasing Zr content (numerical values tabulated). Even though antecedent cold-working depresses the SD activation energy of the Mo in Mo-Zr alloys, the activation energy of upset specimen increases with increasing Zr content. Inasmuch as the diffusion anneal of the deformed alloys was performed at a T substantially above their recrystallization T, the latter was completed in but a fraction of the anneal time, and the diffusion in the grain volume continued through an extended time in the absence of any structural transformation, so that any observed lowering of the SD activation energy of the Mo is regarded as a result of irreversible structural changes attributable to the cold-working of the alloy. The increase in activation energy during the anneal is attributed to a healing of crystalline-lattice defects which previously had served as "short-cut paths" for the diffusion; cold-working appears to firm up the defects, thereby inhibiting the healing effect of the anneal. The relationship between the SD coefficient and the activation energy is further examined and, in agreement with G. J. Dienes (J. Appl. Phys., v.21, no.11, 1950, 1189) and 3 Soviet authors, is found to be exponential. The results of this investigation agree with existing knowledge on the favorable effect of relatively small additions to Mo on its recrystallization T, its hardness (ref. Pipitz, E., Kieffer, R.. Zs. f. Metallkunde, v.46, no.3, 1955, 187-194), and its high-T stress-rupture strength (Northcott, L. Molybdenum. Russian translation, Moscow. Foreign Lit. Publ. House, 1959, 107-108). There are 2 figures, 4 tables, and 16 references (11 Russian-language Soviet, 1 German cited above, 4 English-language of which 1 is a Russian translation).

ASSOCIATION: None given.

S/129/62/000/009/001/006
E071/E492

AUTHORS: Bokshteyn, S.Z., Doctor of Technical Sciences, Professor, Bronfin, M.B., Engineer, Kishkin, S.T., Doctor of Technical Sciences, Professor, Moroz, L.M., Candidate of Technical Sciences

TITLE: Grain boundaries on recrystallization

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, no.9, 1962, 6-8

TEXT: This is a continuation of earlier work ("Zavodskaya laboratoriya", no.10, 1960). The behaviour of W, Ni, Sn and C admixtures present at the grain boundaries during recrystallization of iron (0.021% C, 0.014% P, 0.011% S, 0.67% Si, 0.07% Al, 0.08% Mn, 0.06% Ni, 0.033% Cu) was studied by autoradiographic investigation and microstructural analysis. The admixtures, forming with iron substitutional solid solutions in the case of W, Ni, Sn and interstitial solid solutions in the case of C, were introduced by diffusion saturation at 600 to 700°C. The recrystallization was carried out after preliminary deformations of 10 to 15 and 50 to 70%. The Ni, W and Sn were completely
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soluble in iron at all recrystallization temperatures investigated and remained in their original lattice positions, despite substantial changes in the structure of the metal. The behaviour of carbon atoms was substantially different: above 750°C carbon passed from the boundaries of deformed grains to the boundaries of new recrystallized grains. However, in the initial stages of recrystallization (after 30 to 45 min at 650 to 750°C) carbon atoms remain at the boundaries of the initial grains and boundaries of the new grains remain free from carbon. The possibility of "heredity", i.e. preservation of the initial structural and concentration non-uniformities in recrystallized metal was demonstrated on a molybdenum alloy (0.54% Zr, 0.003% Cr, 0.0008% Ti and 0.011% C). A thin layer of tungsten 185 was electrodeposited on the surface of a flat specimen of the deformed alloy, submitted to a preliminary annealing at 1700°C. The activated specimen was then annealed in vacuo at 1750°C for 100 hours. Autoradiographs of an oblique section showed the presence of an accelerated diffusion not only along the boundaries of the newly formed grains but also a preferential penetration of the W^{185} along those sections where old grain boundaries were passing before recrystallization. The velocity of diffusion along the old boundaries was lower than along the new boundaries, nevertheless it was noticeably faster than volume diffusion. The results confirmed that within the grains the process of grain boundary migration does not produce as high concentration of defects as is produced at the beginning and at the end of the boundary migration. There are 6 figures.

BOKSHTEYN, S.Z.; KISHKIN, S.T.; SVETLOV, I.L.

Breaking test for whiskers of copper, nickel, and cobalt crystals. Fiz.tver.tela 4 no.7:1735-1742 Jl '62.

(MIRA 16:6)

(Strength of materials--Testing) (Metal crystals)

S/032/62/028/005/006/009
B117/B101

AUTHORS: Bokshteyn, S. Z., and Svetlov, I. L.

TITLE: Determination of shape and size of cross section in filiform crystals

PERIODICAL: Zavodskaya laboratoriya, v. 28, no. 5, 1962, 595 - 596

TEXT: The strength of filiform crystals is said to be best determined from the shape and size of cross section on the crystal fracture point. The cold-hardening plastic 712-9M-XO (712-9M-KhO) was used in devising a method of producing microcuts and of determining the shape and size of the cross section. The plastic was poured into a special frame to prevent the crystal from warping and, after polymerization, the microcuts were produced by the usual method, and examined with an МБИ-6 (MBI-6) microscope under 2000-fold magnification. More than 50 threadlike copper crystal cuts were examined in this way. The cross sections of crystals obtained by reduction of copper iodide were mostly hexagonal, less frequently square of rectangular; a good number were of bizarre shapes. The range of areas, s, of

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L 13985-65 EWT(1)/EWT(m)/EWP(e)/EWP(t)/EPF(n)-2/EWA(d)/T/EWP(k)/EWP(w)/EWP(t)
SSD/AFWL/ASD(f)-2/ASD(m)-3 JD/JG/MLK

ACCESSION NR: AT4048127 S/0000/63/000/000/0123/0127

AUTHOR: Bokshteyn, S. Z., Bronfin, M. B., Marichev, V. A.

TITLE: Effect of preliminary plastic deformation on the internal friction of molybdenum and molybdenum alloys

SOURCE: Vsesoyuznaya konferentsiya po relaksatsionny*m yavleniyam v metallakh i splavakh, 3d, Voronezh, 1962. Relaksatsionny*ye yavleniya v metallakh i splavakh (Relaxation phenomena in metals and alloys); trudy* konferentsii. Moscow, Metallurgizdat, 1963, 123-127

TOPIC TAGS: molybdenum, molybdenum alloy, internal friction, molybdenum plastic deformation.

ABSTRACT: The authors investigated the relationship between the temperature of maximum internal friction connected with plastic deformation and the grain size, in an attempt to explain the shift of the deformation maximum toward high temperatures when the grain size increases. Molybdenum powder and cast binary alloys of molybdenum with zirconium (0.13% Zr) and rhenium (50% by weight of Re) were tested; the 110-120 mm wire samples were tested on a torque pendulum in a vacuum

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ACCESSION NR: AT4048127

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of 10^{-5} mm Hg. The heating rate was 2 deg/min. in the 20-1000C range. Maximum deformation was below 10^{-5}. The torque oscillation frequency for measuring internal friction was 0.35-0.40 cycles/sec. Hydrochloric acid in an alcoholic solution was used for electrolysis of the sample to increase the internal friction. All alloys passed through recrystallization at three different temperatures. The maximum of internal friction after preliminary plastic deformation was on the high temperature side, but the internal friction constantly decreased as the annealing temperature increased, especially between 200 and 600C. In the discussion, it is pointed out that modern theory considers the crystal structure to be a three-dimensional lattice, segments of which may bend under low stress. The equation derived in the paper shows that the modulus of elasticity of materials with dislocations is lower than for materials without dislocations. Plastic deformation thus increases the dislocation density in the metal grains, lowering the effective modulus of elasticity and increasing internal friction. The maximum of internal friction connected with plastic deformation is reached only for a certain relationship of degrees of freedom of oscillating dislocations and introduced atoms of admixtures. The irreversible lowering of internal friction at temperatures exceeding the maximum temperature is caused in the opinion of the authors, not only by an increase in the diffusion mobility of the introduced atoms, but also

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ACCESSION NR: AT4048127

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by the lowering of relatively free dislocations due to polygonization. The lack of a maximum connected with plastic deformation for the molybdenum-rhenium alloy indicates that there is a great difference between the deformation of this alloy and that of the molybdenum-zirconium alloy or pure molybdenum. For the rhenium alloy, plastic deformation is not accompanied by the quantity of relatively free dislocations, which lead to the appearance of the deformation maximum of internal friction in the alloy with Zr. Orig. art. has: 4 figures and 2 formulas.

ASSOCIATION: Vsesoyuznyy institut aviatsionnykh materialov (All-Union Institute of Aviation Materials)

SUBMITTED: 10Nov63 ENCL: 00 SUB CODE: MM

NO REF SOV: 001 OTHER: 001

Card 3/3

L 11227-63 EWP(q)/EWT(m)/BDS--AFFTC/ASD--JD

ACCESSION NR: AP3000488

S/0129/63/000/005/0040/0044

56

AUTHOR: Bokshteyn, S. Z.; Kishkin, S. T.; Nikishov, A. S.; Polyak, E. V.; Solov'yeva, G. G.

TITLE: Aging of plastically deformed alloys

SOURCE: Metallovedeniye i termicheskaya obrabotka metallov, no. 5, 1963, 40-44

TOPIC TAGS: thermomechanical treatment, high temperature, low temperature, heat resistant steel, heat resistant alloy, titanium alloy, aging, mechanical properties, rupture life

ABSTRACT: A review of published reports on thermomechanical treatment of steels and alloys (TMT) indicates that TMT has a beneficial effect on rupture strength only up to a certain temperature. At higher temperatures the diffusion processes which cause softening proceed at a considerably higher rate than in conventionally treated alloys. For instance, an Ni-Cr-W-Mo-Ti-Al alloy [unidentified] after TMT and aging had a rupture life at 850C 30 to 40% lower than conventionally treated alloys, although its tensile strength was 25% higher. At lower service temperatures (550C for Ni-base alloys and 450 to 500C for Ti-base alloys) TMT greatly increases creep strength and rupture life, especially when combined with aging.

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ACCESSION NR: AP3000488

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The optimum combination of tensile strength, notch toughness, and rupture life for the KhNGGTYuR alloy [Nimonic 80A] is obtained by plastic deformation at 1000 to 1050C with a reduction of ~ 30% followed by aging. The VTZ-1 Ti-base alloy, forged at 920C, water quenched, and aged at 550C for 2 hr, had a tensile strength at room temperature of 145.5 kg/mm², elongation of 9.4%, reduction of area of 47%, a notch toughness of 2.0 mkg/cm², and a rupture life (at 450C under 52 kg/mm² stress) of over 150 hr; corresponding figures for a conventionally treated alloy were 117.0 kg/mm², 12%, 34%, 2.9 mkg/cm², and 108 hr. Still greater effects can be achieved by two-stage TMT: deformation at 1200C followed by water quenching; reheating to 1000C and a second deformation with a reduction of 5 to 10%, followed by water quenching and aging. After such treatment the alloy had a rupture life of 200 hr at 550C under a stress of 92 kg/mm² and 100 hr at 650C under a stress of 62 kg/mm²; corresponding figures for conventionally treated alloys were 3 to 7 hr and 60 hr. Combined treatment of the 1Kh12N2VMF steel (forging with 60% reduction at 1010C, water quenching, sizing at 600C with 5 to 10% reduction, combined with aging for 2 hr) increased the tensile strength at 20C by 40% and at 450C by 60%, and the rupture life (at 450C under a stress of 75 kg/mm²) by 250%. Orig. art. has: 4 figures and 3 tables.

ASSOCIATION: none

Card 2/2

BLISTANOV, A.A.; BOKSHTEYN, S.Z.; GUDKOVA, T.I.; ZHUKOVITSKIY, A.A.; KISHKIN, S.T.

Investigating the effect of stress on porosity forming. Issl. po zharoproch. splav. 10:81-86 '63. (MIRA 17:2)

ACCESSION NR: AT4013954 S/2659/63/010/000/0214/0218

AUTHOR: Bokshteyn, S. Z.; Kishkin, S. T.; Moroz, L. M.

TITLE: Condition of grain boundaries during recrystallization

SOURCE: AN SSSR. Institut metallurgii. Issledovaniya po zharoprochny*m splavam, v. 10, 1963, 214-218

TOPIC TAGS: metal fatigue, steel grain, recrystallization, grain boundary

ABSTRACT: The present investigation dealt with two problems: First, whether or not the atoms of the initial grain boundary serve as the boundary of the newly-crystallized grains and second, whether or not the initial grains leave traces of their inadequate structure, i.e., whether their inadequacies are completely eliminated during recrystallization. Radioactive isotopes were used for the investigation of the grain boundaries during recrystallization of molybdenum, nickel, iron and iron containing various impurities. The results showed that the atoms of the base metal grain boundary do not take part in creating the grain boundaries of the recrystallized metal and that the boundaries of the recrystallized grains inherit some of the structural features of the initial grain. Orig. art. has: 3 figures.

ASSOCIATION: Institut metallurgii AN SSSR (Institute of Metallurgy AN SSSR)

ACCESSION NR: AT4013954

SUBMITTED: 00

DATE ACQ: 27Feb64

ENCL: 00

SUB CODE: MM

NO REF SOV: 000

OTHER: 000

Card 2/2

L 10502-63 EWP(q)/EWT(m)/BDS--AFFTC/ASD--JD

ACCESSION NR: AP3001307 S/0181/63/005/006/1749/1750

AUTHOR: Bokshteyn, S. Z.; Svetlov, I. L. 54

TITLE: The effect of alloying on the strength properties of copper whiskers

SOURCE: Fizika tverdogo tela, v. 5, no. 6, 1963, 1749-1750

TOPIC TAGS: copper whisker, copper-silver alloy-whisker, strength, alloying, silver, impurity, size effect

ABSTRACT: In an attempt to explain the high strength exhibited by whiskers of certain substances, the role of impurities was investigated. Copper whiskers dusted in a vacuum of 10^4 mm Hg with silver powder were annealed in vacuum or in a stream of hydrogen under conditions assuring diffusion of the silver to the center of the thickest whisker. The alloyed whiskers were then subjected to a tensile test. Alloyed whiskers more than 4.5 μ in diameter were found to be stronger than the same size pure-copper whiskers; for small diameters the reverse was true. The dependence of strength on diameter (size effect) is far less marked in alloyed whiskers than in pure-copper whiskers. In thick whiskers,

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L 10502-63
ACCESSION NR: AP3001307

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where the density of structural defects is high, silver apparently acts as a strengthener and the strengthening mechanisms are apparently the same as those usually associated with alloying (formation of a solid solution or precipitation of a second phase). Impurities in thin whiskers (d less than 4.5 μ), however, apparently impair the perfectness of the crystal lattice and facilitate the nucleation of dislocations, thereby reducing the strength of the whiskers. Orig. art. has: 1 figure.

ASSOCIATION: none

SUBMITTED: 08Feb63 DATE ACQ: 01Jul63 ENCL: 00

SUB CODE: MA NO REF SOV: 001 OTHER: 000

ss/*W*
Card 2/2

BALALAYEV, Yu.F.; BOKSHTEYN, S.Z.

Ultrasonic high temperature heating and its use for heat treatment in the investigation of metals and alloys. Fiz. met. i metalloved. 16 no. 6:872-876 D '63. (MIRA 17:2)

1. Voronezhskiy politekhnicheskiy institut.

DUBININ, G.N.; BOKSHTEYN, S.Z., doktor tekhn. nauk, prof., retsenzent; GRIBOYEDOV, Yu.N., kand. tekhn. nauk, retsenzent; MINKEVICH, A.N., kand. tekhn. nauk, red.

[Diffusion chromizing of alloys] Diffuzionnoe khromirovanie splavov. Moskva, Mashinostroenie, 1964. 450 p.
(MIRA 17:11)

ACCESSION NR: AT4040405 S/0000/64/000/000/0025/0035

AUTHOR: Bokshteyn, S. Z.; Bronfin, M. B.; Kishkin, S. T.

TITLE: Surface and bulk diffusion of tungsten in molybdenum

SOURCE: Protsessy* diffuzii, struktura i svoystva metallov (Diffusion processes, structure and properties of metals); sbornik statey. Moscow, Izd-vo Mashinostroyeniye, 1964, 25-35

TOPIC TAGS: tungsten, molybdenum, surface diffusion analysis, bulk diffusion analysis, autoradiographic analysis method, activity curve analysis method, diffusion coefficient, diffusion equation, diffusion activation entropy, vacancy formation energy

ABSTRACT: The radioactive isotope W^{185} was electroplated on fine-grained flat plates of Mo for autoradiographic analyses of bulk diffusion and surface diffusion, as well as on coarse-grained cylindrical samples for bulk diffusion analyses based on displacements of activity curves. Diffusion coefficients were determined for all samples (see Table 1 in the Enclosure) and further processing yielded the equations

$$D = 3.18 \exp[-(112900 \pm 1000)/RT] \text{ cm}^2/\text{sec}$$

ACCESSION NR: AT4040405

for bulk diffusion and

$$D_{surf} = 1.1 \exp(-77000/RT) cm^2/sec$$

for surface diffusion. It is concluded that the entropy of activation of Mo self-diffusion is greater than zero, in agreement with Zener's theory of D_o for atomic diffusion, and approximate values for the entropy of activation of W diffusion in Mo. Energy of vacancy formation Q_o = 36 kcal/g-atom, ratio Q_o/Q_{diff} = 0.3 to 0.4 (0.32 for Mo, 0.39 for Cr). Orig. art. has: 8 formulas, 4 figures and 4 tables.

ASSOCIATION: none

SUBMITTED: 09Dec63 DATE ACQ: 28May64 ENCL: 02

SUB CODE: MM NO REF SOV: 011 OTHER: 012

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ACCESSION NR: AT4040405 ENCLOSURE: 01

Table 1. Diffusion coefficient in cm^2/sec. for diffusion of W in No.

Temp. of diffusion annealing in °C	1700	1750	1830	1850	1880	1900
Bulk diffusion, activity curve displacement analysis (hrs.)	—	—	5.8×10^{-12} (47.5)	—	1.1×10^{-11} (109.5)	—
Bulk diffusion, autoradiographic analysis (hrs.)	9.9×10^{-12} (112)	2.0×10^{-12} (108)	—	8.9×10^{-12} (103)	—	1.2×10^{-11} (99)
Intercrystalline diffusion	—	5.4×10^{-9}	—	1.3×10^{-8}	—	2.0×10^{-8}

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ACCESSION NR: AT4040405

ENCLOSURE: 02

1950	2100
3.1×10^{-11} (59)	1.25×10^{-11} (24)
—	—

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ACCESSION NR: AT4040407 S/0000/64/000/000/0040/0051

AUTHOR: Bokshteyn, S. Z.; Bronfin, M. B.; Kishkin, S. T.; Marichev, V. A.

TITLE: Investigation of conditions at the grain boundaries in molybdenum and its alloys with zirconium and rhenium by the method of internal friction

SOURCE: Protsessy* diffuzii, struktura i svoystva metallov (Diffusion processes, structure and properties of metals); sbornik statey. Moscow, Izd-vo Mashinostroyeniye, 1964, 40-51

TOPIC TAGS: molybdenum, molybdenum alloy, molybdenum grain boundary, molybdenum rhenium alloy, molybdenum zirconium alloy, rhenium, zirconium, internal friction, stress relaxation, alloy diffusion

ABSTRACT: The mechanism of stress relaxation at the grain boundaries in pure metals is known to be affected by the presence of alloying elements, but precisely how is still unclear. The study of internal friction, based on measurement of the forced oscillation dampening of a polycrystalline specimen is a sensitive method for investigation of the structural conditions of a metal generally, and particularly at the grain boundaries. The present authors experimented with specimens of 99.98% pure sintered molybdenum; a Mo - Zr alloy containing 0.13% Zr,

ACCESSION NR: AT4040407

0.008% C, 0.006% O_2, and 0.0007% H_2; and Mo+50% Re. The specimens were subjected to torsional oscillations (0.3-0.4 cycles/sec.) at various temperatures in a range of about 20 - 1000C, after annealing at temperatures up to 2000C. The test installation was originally developed by V. B. Osvenskiy and is shown schematically in modified form, in Fig. 1 of the Enclosure. The activation energy H of internal friction was determined from the expression

$$\log Q^{-1} = \log \frac{\Delta M}{\omega \tau_0} - 0.4346 \frac{H}{RT}$$

under the assumption that $\log \frac{\Delta M}{\omega \tau_0} = \mathrm{const.}$ Fig. 2 of the Enclosure shows the temperature dependence of Q^{-1} for the 3 materials compared. The results showed that the boundary relaxation begins to grow at different temperatures in different alloys. Thus, this temperature is 700C for the Mo-Re alloy and about 600C for pure molybdenum or Mo+0.13% Zr. Beginning at 700C, the highest level of internal friction is shown by unalloyed molybdenum; the lowest - by its alloy with 50% rhenium. If the internal friction along the grain boundaries depended only on the activation energy, it should be maximal in the Mo-Zr alloy, and not in

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pure molybdenum. A mechanism of boundary relaxation is therefore suggested which is connected with a migration of interstitial solutes such as oxygen, carbon and nitrogen. This migration requires less energy than the displacement of the diffusionally more inert atoms normally occupying the nodal points in the lattice. This could explain the relatively low activation energy of internal friction found at the grain boundaries. Qualitatively, the influence of diffusional replacement components can be explained by the mutual interaction between these components and the migrating atoms of penetrating components, as well as the ability of the replacement components to alter the structural imperfections in intergranular zones. "The authors express thanks to Ye. M. Savitskiy and M. A. Tylkina for supplying the Mo-Re alloy." Orig. art. has: 5 figures and 4 formulas.

ASSOCIATION: None

SUBMITTED: 09Dec63 ENCL: 02

SUB CODE: MM NO REF SOV: 003 OTHER: 005

Card 3/5

ACCESSION NR: AT4040411 S/0000/64/000/000/0074/0094

AUTHOR: Bokshteyn, S. Z.; Kishkin, S. T.; Moroz, L. M.

TITLE: Investigation of the conditions of the grain boundaries during recrystallization of iron and its alloys

SOURCE: Protsessy* diffuzii, struktura i svoystva mettallov (Diffusion processes, structure and properties of metals); sbornik statey. Moscow, Izd-vo Mashinostroyeniye, 1964, 74-94

TOPIC TAGS: iron, iron alloy, steel, tungsten steel, carbon steel, steel structure, grain boundary, recrystallization, iron microstructure, carbon diffusion, tungsten diffusion, tin diffusion, nickel diffusion

ABSTRACT: There are still unclear aspects of the mechanism of recrystallization, such as the nature of the reconstruction of grain boundaries, the formation of new grains and their subsequent growth, the influence of impurities, and the role of diffusion. The present authors investigated recrystallization of iron in specimens previously subjected to a plastic deformation of 10-16 and 45-70%, involving a variety of heat treatments (annealing at 720-800C, recrystallization at 700-1370C, additional heating at 700-950C). Data on microhardness before and after these processes are tabulated. Furthermore, recry-

ACCESSION NR: AT4040411

stallization was investigated on specimens of iron in which impurities were located at the iron grain boundaries, formed a part of the solid solution by replacement or formed a part of the solid solution by penetration; here again, various degrees of plastic deformation and various heat treatments were applied. The impurities tested were carbon, tin, tungsten and nickel. Finally, radioactive isotopes were used as tracers to observe local displacements of atoms by radio autographs, as well as by photomicrographs and X-ray radiographs. In order to study the behavior of base-metal atoms, the isotope Fe^{59} was used; for the behavior of atoms of an alloying elements, a corresponding isotope of the alloying element was employed. Test specimens 10 x 10 x 20 mm were cut from iron bars previously annealed (1250 C for 9 hrs.) in order to obtain a homogeneous structure and a coarser grain for the convenience of radiographic investigation. After cutting, the work-hardened surface layer (70-80 microns) was removed by electrolytic polishing. The radioactive tracer was deposited on the polished surface electrolytically. Diffusion annealing was carried out in a vacuum furnace at residual pressures of 10^{-3} - 10^{-4} mm Hg. The temperature of diffusion annealing was 720C, at which the influence of grain boundaries on the diffusional flux has been found to be particularly pronounced. Deformation of specimens was carried out in a 200-ton Amsler press. An analysis of the experimental results showed that atoms of soluble impurities (nickel, tungsten, tin), like the atoms of the base-

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showed that atoms of soluble impurities (nickel, tungsten, tin), like the atoms of the base-metal, practically remain at their initial locations despite significant changes in the micro-structure of the metal. Prolonged annealing at recrystallization temperature (78 hrs. at 700C for iron with nickel; 30 hrs. for iron with tin; 28 hrs. at 750 C for iron with tungsten), heating at temperatures above the A_3-point, or high-temperature annealing (30 min. at 1200 C for iron with tungsten) did not cause atomic migration of impurities from the initial locations toward the boundaries of the recrystallized grains, regardless of the degree of prior deformation. During recrystallization, atoms of impurities which were located at the grain boundaries and formed part of the solid solution by penetration showed a substantially different behavior than atoms of base-metal at the boundaries or atoms of impurities forming part of the solid solution by replacement. Carbon atoms, unlike atoms of iron, tungsten, nickel, and tin, follow behind the boundaries of newly forming grains, so that at certain stages of the process a lag may occur due to a difference between the diffusion velocity of carbon and the recrystallization velocity. It is characteristic that carbon atoms always migrate toward the grain boundaries, and not in the direction of the maximum concentration gradient of the impurity. The authors suggest, in conclusion, that the activation energy of the migration process be determined and compared with the activation energy of the diffusion process of carbon in iron. Orig. art. has: 25 photomicrographs and 3 tables.

ASSOCIATION: None

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ACCESSION NR: AT4040413 S/0000/64/000/000/0099/0109

AUTHOR: Bokshteyn, S. Z; Kishkin, S. T.; Moroz, L. M.; Chaply*gina, V. S.

TITLE: Structure imperfections of metal following recrystallization

SOURCE: Protsessy* diffuzii, struktura i svoystva metallov (Diffusion processes, structure and properties of metals); sbornik statey. Moscow, Izd-vo Mashinostroyeriye, 1964, 99-109

TOPIC TAGS: metal structure, metal diffusion, diffusion permeability, metal recrystallization, iron, tin, tungsten, carbon diffusion

ABSTRACT: Many of the properties and processes occurring in metals depend upon the degree of structural perfection. However, it is not clear how and under what circumstances structural defects arise or disappear. In some cases, it has been possible to achieve a displacement of interstitial impurities into the inner regions of grains by recrystallization, thus increasing the plasticity of the alloys. However, such a beneficial influence of recrystallization has been observed only in individual cases. Therefore, the assumption can be made that in regions where grain boundaries have been located before recrystallization, preservation of the specific state is possible, i.e., there is a possibility

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of "heredity". In the present paper, the authors investigated the heredity of metal structure during recrystallization and grain growth, using autoradiographic and microscopic techniques. The degree of structural perfection was evaluated by diffusion permeability of C^{14}, a higher permeability corresponding to a more defective structure. Using specimens of pure iron and of iron containing diffusionally introduced interstitial additions, such as tin and tungsten, the authors studied the stability and degree of defectiveness of the original grain boundaries during recrystallization in relation to the degree of metal purity and the recrystallization conditions. Iron was annealed at 1250C for 9 hrs., electropolished and etched with 4% picric acid in ethanol to reveal the structure. Tin and tungsten were added in a microfurnace at 700C. Recrystallization was then carried out either at 650C for 45 min., at 700C for 30 min. or at 750C for 1 hr., followed by heating at 600C for 1 hr. in the presence of radioactive carbon. Measurements of hardness and C^{14} distribution demonstrated that diffusion is affected by recrystallization temperature and that the residual effects of previous cold working can remain after application of the common types of recrystallization. The diffusional mobility of atoms was found to increase during the process of recrystallization. Failure of alloys at high temperatures generally proceeds along the grain boundaries, but sometimes it occurs transgranularly. It is possible that, in the latter case, the alloy fails along the boundaries of original

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grains which were metallographically undetectable. The question of the influence of various impurities on the defectiveness of the original grain boundaries thus gains considerable significance. It is very possible that inheritance of defectiveness is linked to a considerable degree to the presence of impurities; therefore, the question arises of the possibility of displacing the impurities from the boundaries to the inner region by recrystallization. The results of the present investigation permit the authors to assume that the detrimental influence of impurities can be reduced by applying suitable recrystallization conditions. Orig. art. has: 7 figures and 1 table.

ASSOCIATION: none

SUBMITTED: 09Dec63 DATE ACQ: 28May64 ENCL: 00

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ACCESSION NR: AT4040414 S/0000/64/000/000/0110/0112

AUTHOR: Bokshteyn, S. Z.; Bronfin, M. B.

TITLE: Effect of hereditary structure in molybdenum and its alloys

SOURCE: Protsessy* diffuzii, struktura i svoystva metallov (Diffusion processes, structure and properties of metals); sbornik statey. Moscow, Izd-vo Mashinostroyeniye, 1964, 110-112

TOPIC TAGS: molybdenum, molybdenum zirconium alloy, alloy structure, hereditary structure, structure effect

ABSTRACT: The effect of hereditary structure (residual structure defects in regions corresponding to the original grain boundaries) in molybdenum and molybdenum-zirconium alloys was investigated by the method of tagged atoms. A layer of W^{185} was electrically deposited on the surface of specimens vacuum annealed (10^{-3}—10^{-4} mm Hg) at 1700C for 14 hr. The specimens were then held at 1750C for 108 hr. The growth of the molybdenum grains at 1750C was completed in 100 min and no further change in grain size occurred in the succeeding 10,000 min. The autoradiograms of the diffusion zone showed that W^{185} penetrates not only along the grain boundaries formed at 1750C but also along the

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initial grain boundaries, i.e., those which existed prior to diffusion annealing. This indicates that even prolonged diffusion annealing does not eliminate structural defects in places where the initial grain boundaries were located. In the molybdenum-zirconium alloy (0.54% zirconium) the phenomenon was expressed much more sharply than in unalloyed molybdenum, owing probably to the presence of very stable zirconium compounds (either oxide or carbide type). The diffusion along the new grain boundaries was more intensive, which indicates a higher density of defects than is found along the old boundaries. It is suggested that the phenomenon observed can be utilized for improving the ductility of molybdenum at room temperature. Under certain conditions at recrystallization it could be expected that the old boundaries would serve as a kind of trap for the atoms of harmful interstitials such as carbon, oxygen, and nitrogen, and would thus reduce the content of these interstitials in the new grain boundaries. Orig. art. has: 2 figures.

ASSOCIATION: none

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ACCESSION NR: AT4040415 S/0000/64/000/000/0113/0116

AUTHOR: Balalayev, Yu. F.; Bokshteyn, S. Z.

TITLE: Behavior of the grain boundaries in iron during ultrasonic high-temperature heating

SOURCE: Protsessy* diffuzii, struktura i svoystva metallov (Diffusion processes, structure and properties of metals); sbornik statey. Moscow, Izd-vo Mashinostroyeniye, 1964, 113-116

TOPIC TAGS: iron, iron grain boundary, iron microstructure, grain boundary, ultrasonic heating

ABSTRACT: In view of the wide use of hot recrystallization during the production of austenitic steel, the authors investigated the behavior of the grain boundaries during ultrasonic recrystallization of iron containing 0.04% C, 0.07% Mn, 0.03% Si, 0.035% S, and 0.015% P. In order to obtain a homogeneous fine-grained structure, the specimens were annealed at 950C for 1 hour, and were then subjected to ultrasonic vibrations at 19.5 kilocylces/sec., resulting in a temperature of more than 1000C at the node. Cuts for micrographic investigation were made axially through the specimens, and the cold worked surface layers were removed by electropolishing, followed by etching to reveal the microstructure. The microstructure